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A Neglected Ricardian Aspect Of Labor Supply

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A Neglected Ricardian Aspect Of Labor Supply

Abstract

In this paper we develop and estimate a model of the supply of personal services, which is applied to physicians. Typically the services are embodied in the consumers who demand them, in the sense that resale is costly. At least this is true of medical care, which according to a recent analysis (Grossman, 1972) is combined with personal contributions to health such as exercise time to create "additions to the patient's health. Our view of the supply of medical care emphasizes the choice between treating a smaller number of patients (more generally, dealing with a smaller number of clients) more intensively and a larger number less intensively, a choice which we term the Extensive-Intensive Allocative Question,

Disciplines

Behavioral Economics | Economic Theory | Equipment and Supplies | Health Economics | International and Comparative Labor Relations

A NEGLECTED RICARDIAN ASPECT

OF

LABOR SUPPLY

(With an Application to Canadian Physician's Data

by

James D. Adams

#64

Part A: Theory

I. Introduction

In this paper we develop and estimate a model of the supply of personal services, which is applied to physicians. Typically the services are embodied in the consumers who demand them, in the sense that resale is costly. At least this is true of medical care, which according to a recent analysis (Grossman, 1972) is combined with personal contributions to health such as exercise time to create additions to the patient's health.^{1/} Our view of the supply of medical care emphasizes the choice between treating a smaller number of patients (more generally, dealing with a smaller number of clients) more intensively and a larger number less intensively, a choice which we term the Extensive-Intensive Allocative Question. Our analysis resembles Ricardo's famous discussion of the margins of land cultivation, but is to be sharply distinguished from previous studies of intensity of factor use (Rosen, 1968, 1969; Nadiri and Rosen, 1974). These studies investigate the interrelations of stock input measures such as employment and capital, and intensity of input measures such as hours per man and the capital utilization rate. Our analysis in marked contrast examines the interaction between physician hours per patient and the number of patients, even holding constant total hours of work per physician and his utilization of hospital and clinic services. This difference arises from our interest in the allocation of work effort to consumers, as opposed to the demand for intensity of factor use by firms.

Physicians, according to our approach, combine their own services and other inputs such as nursing care, and medical equipment services to produce medical care for each patient separately, so that treatment of each patient can be compared to a miniature production process. Our view of the medical practice treats the physician as a multiple job holder who decides on the number of jobs (patients) he wishes to hold by choosing the size of practice; while for the most part, in a sense later described, we rely on demand conditions to determine the quantity of medical services per patient, and indirectly, physician hours per patient. Nevertheless, the amount of time in each job (i.e., spent with each patient) is regarded as flexible so that our analysis bears a closer resemblance to the model of Huffman (1977) than to the model of Shisko and Rostker (1976) among the previous studies of multiple job holding.^{2/}

The existence of unmeasured variation in the quality of medical care creates problems of interpretation and estimation in most models of medical care, and ours is no exception.^{3/} In particular, the interpretation of price data is made ambiguous since price can reflect hidden quality variations and the usual quantity data tend to omit them.^{4/} Since our central focus is upon the Intensive-Extensive Allocative Question, we do not develop a full Hedonic model, though we indicate at various points how we would modify our analysis to accommodate choice of quality as well as quantity, and we attempt in the empirical work to control for quality variation by stratifying regression samples by type of medical care, and entering physician characteristics in the price and quantity regressions for the restricted samples.

The remainder of Part A is arranged as follows. Section II presents a model of the demand for health care which is a modest variation on the theory of demand for health developed by Grossman (1972) and is accordingly brief. Its implications are developed for the allocation of working time

and medical facilities by physicians. Section III develops a model of physician's labor supply which centers on the Intensive-Extensive Allocative Question and includes the choice of supplying multiple qualities of care.

II. The Demand for Medical Care

Patients in our analysis are utility maximizers who can alter available or healthy time and their wage rate by adding to their health.^{5/} Since healthy days and therefore health may enter the patient's utility function, health may be a consumer's as well as a producer's good. The patient combines time devoted to increasing health with different kinds of medical care using a household production function which depends on his personal characteristics. In this paper, we treat quality of medical care as discrete, impounding all other differences in care in a residual standing for unmeasured variations in quantity. There is a finite number q of qualities of medical care, a view which we believe harmonizes well with our data; one can undergo an appendectomy or tonsillectomy, and the physician with more excellent training or longer experience simply supplies more services per hour than his lesser skilled counterpart.

The utility function of the patient depends on market goods X , leisure L , and perhaps healthy time F , defined as total time T minus sick time S , or $F = T - S$.^{6/} Thus his utility function is

$$U = U(X, L, F). \quad (1)$$

The patient allocates his time subject to a total time constraint,

$$T = L + H + M + S, \quad (2)$$

where H = work time, M = time devoted to health care. His money income constraint is

$$WH + V = PX + \sum_{j=1}^s R_j Q_j, \quad (3)$$

where W is the patient's wage, V his unearned income, P the price of market goods he consumes, R_j the price, and Q_j the quantity of the j -th quality of medical care which he purchases. Finally, healthy time ($F \equiv T - S$) and the wage rate are assumed to be positive functions of health, where health is the sum of an endowed level E_0 and a net addition I . Therefore we write

$$F = F(E_0 + I), \quad F' > 0 \quad (4)$$

$$W = W(E_0 + I), \quad W' > 0. \quad (5)$$

The production function for I depends on health care time M and medical care Q_j ($j = 1, \dots, s$), so

$$I = I(M, Q_1, \dots, Q_s), \quad (6)$$

where positive marginal products of health care inputs are assumed.^{7/}

The Lagrangean function corresponding to equations (1) through (6) is

$$L = U(X, L, F) + \lambda[W(T - L - S - M) + V - PX - \sum_1 R_j Q_j]. \quad (7)$$

First order conditions are

$$U_L - \lambda W = 0 \quad (8)$$

$$U_X - \lambda P = 0 \quad (9)$$

$$U_F F' I_M + \lambda(W'H I_M - W + W F' I_M) = 0 \quad (10)$$

$$U_F F' I_{Q_j} + \lambda(W'H I_{Q_j} - R_j + W F' I_{Q_j}) \leq 0, \quad (11)$$

$$j = 1 \dots s$$

where $U_F = \frac{\delta U}{\delta F}$, $I_M = \frac{\delta U}{\delta M}$, etc. Abstracting from the value of health as a consumer's good, so that $U_F = 0$, conditions (10) and (11) can be interpreted to mean that the marginal cost of health care inputs equals or exceeds the value of their marginal product, or

$$W = (W'H + W F') I_M \quad (10)'$$

$$R_j \geq (W'H + W F') I_{Q_j}; \quad (11)'$$

where $W'H + W F'$ is the shadow price of additions to health, which is the sum of the value of incremental wages ($W'H$) and the value of additional time ($W F'$). Notice that we have allowed for the possibility that purchases of medical care of type j may be zero.

Our main interest lies in the demand for medical care, and shifts in this demand.^{8/} A higher wage W , greater responsiveness of wages to health W' , longer working hours H , and greater responsiveness of healthy time to health all imply increased marginal benefits of medical care, larger amounts

purchased, and a greater likelihood of positive purchases,^{9/} In particular, the higher are wage rates and earnings, the greater the demand for medical care.^{10/} Moreover, if healthy days do not enter the utility function, the patient's demand for medical care is affected only by shifts in the monetary costs and benefits, implying that nonwage income does not affect the demand for health care.^{11/}

Additional variables shifting the demand for medical care are patient's age, education and sex, which all enter through the production function for additions to health. Age increases (decreases) the demand for medical care if the demand for health decreases by less (more) than the endowment, even though age raises the cost of maintaining health. Education raises (lowers) the demand for medical care if the saving in medical care is less (more) than the derived increase in demand for medical care due to an education-induced fall in the marginal cost of health.

For our purpose, the main implication of this analysis is that levels of medical care are determined by patients, and shifts in the level of medical care are determined by shifts in the characteristics of patients. Notice that we are not assuming the patient chooses the level of physician's time or other inputs into medical care; rather, he purchases medical care itself, which is a bundle of inputs assembled for him by the physician.^{12/}

Since for a perfectly elastic supply curve in a competitive case, demand wholly determines the amount of medical care, the per capita demand for medical care is wholly determined by the distributions of the patient's wages and their other characteristics.^{13/}

There appear to be two principal counterarguments to this conclusion. First, it is assumed that physicians can increase patient's demand for medical care beyond the utility-maximizing amount. In other words, patients are assumed to be incapable of estimating the effects of treatments, an inability which may be related to the lag in these effects. Since there appears to be

an optimal timing of medical care which creates a sequence of patient visits, excessive medical care (as defined above) is reflected in an excessive number of repeat visits.^{14/} The hypothesis suggests a "knowledge gap" between physicians and patients; if one believes this, then the number of repeat visits is made to depend on some measure of the difference in patient's and physician's information. We propose as an empirical counterpart, the difference in educational levels of physicians and patients.^{15/}

The second counterargument denies for several reasons that the supply of medical care is perfectly elastic to the patient. First, imperfect information renders the price of medical care a function of the patient's search. Since we would expect the patient to search more and pay a lower price the greater is his demand for medical care, the supply curve inclusive of search efforts is downward sloping. Second, imperfect experience rating under medical insurance plans may drive the marginal cost of medical care to the patient below the average cost, implying falling price to the patient.^{16/}

The counterarguments constitute exceptions to the proposition that patients determine the level of medical care, either in the sense that the empirical demand curve is independent of physician's supply, or in the sense that the price of medical care is fixed to the patient, although assessing their importance appears to be econometrically difficult.^{17/}

III. The Physician's Supply of Labor

The physician also maximizes his utility U^* , which we write as a function of market goods X^* and leisure L^* .^{18/} We omit additional consumption variables, because their use is peripheral to our analysis. For example, it has been asserted that physicians behave like Altruists, which leads them to make voluntary contributions in the form of lower price to patients with lower

incomes. We neglect this argument and others, simply because we cannot disentangle their influence from other sources of price variation in the data. Physician utility is maximized subject to net income Y , which is the sum of wage and entrepreneurial income derived from the practice, and property income, less payments to other productive factors used in providing medical care. Our formulation of the physician's sources of income explicitly differentiates between physician hours per patient h , and the number of patients N , where lower case letters indicate per capita variables. Moreover, since medical care is provided on a per patient basis, it depends on per capita inputs of physician's time h and other inputs k . Because the essence of our model can be shown more simply if we assume specialization in providing a single quality of care, the main part of our analysis treats this case, though we show how to extend it to handle multiple qualities of care at appropriate points.

A third equation for the physician's time budget closes the model. The physician's utility function is therefore

$$U^* = U^*(X^*, L^*), \quad (12)$$

which is maximized subject to a (net) money income constraint,

$$Y = P^*X^*, \quad (13)$$

where P^* = price of market goods. Net money income for a homogeneous group of patients is defined as

$$Y = V^* + NR(\alpha)Q[h, k, N_h, \beta] - NS^*k, \quad (14)$$

where V^* = physician's property income, N = number of patients, and Q =

production function for care per patient. We assume positive marginal products for all inputs entering Q . Also R = market price per unit of medical care, S^* = price per unit of cooperating inputs, α = vector of market determinants shifting the price of care, β = vector of determinants shifting the efficiency of medical care. In equation (14) NRQ is the gross value of the practice, NQ the total volume of services, $Nh = H^*$, or total hours of work, and NS^*k is the total cost of other inputs used in the practice, Nk their total volume.^{19/}

Market price R is a function of market conditions α , including short-term disequilibria; and if the physician has monopoly power due to imperfect information, R also depends on the quantity of care per patient Q . Since Q is a per capita production function it depends on per capita inputs h and k , on total work hours NL if there is fatigue, monotony, or boredom [see Chapman (1909) for a discussion of the relative importance of fatigue versus other causes of decline in productivity]; and on a vector of efficiency variables β . Included among the efficiency variables are physician skills (quality of formal training, length of experience), physician health status, and possibly, availability of other inputs.^{20/}

Total work hours are specified as the product of the number of patients N and hours per patient h . If there were fixed time costs per patient f , then total work hours would be the sum of total variable and fixed hours, or $N(h + f)$. Therefore, the physician's time budget (ignoring fixed time costs) is

$$T^* = L^* + H^* = L^* + Nh. \quad \frac{21/}{(15)}$$

The model consisting of equations (12) through (15) has a structure which implies that hours per patient and number of patients are chosen to maximize net income, at any level of total work hours. This follows from the

fact that only total leisure time, and therefore only total work time enter the utility function.

The Lagrangean problem corresponding to this model of utility maximization is, in the simpler case of no fatigue,

$$L = U^* [X^*, T^* - NL] + \lambda^* [V^* + NRQ - NS^*k - P^*X^*], \quad (16)$$

substituting the time budget directly into the utility function. Note that if fatigue is not operating, Q does not depend on total work hours.^{22/}

In a setting where imperfect information or physician-determined demand are important, the physician chooses both the level of medical care per patient and the number of patients. This implies that physician hours per patient and other inputs are chosen independently of each other and total work hours. But if we assume as an approximation that patients choose the level of care which they receive, then $Q = Q_0$, and physician hours per patient cannot be independent of other inputs per patient k , since the physician moves along an isoquant in choosing the method of care. We write

$$h = h(k, Q_0, \beta), \quad (17)$$

to indicate this dependency, where h has been eliminated as an independent variable using the relation $Q = Q_0$.^{23/} First order conditions of (16), subject to the additional constraint (17), are

$$U^*_{X^*} - \lambda^* P^* = 0 \quad (18)$$

$$-U^*_{L^*} h + \lambda^* (RQ - S^*k) = 0 \quad (19)$$

$$-NU^*_{L^*} h_k - \lambda^* NS^* = 0 \quad (20)$$

$$V^* + NRQ - NS^*k - P^*X^* = 0 \quad (21)$$

where $U^*_{X^*} = \frac{U^*}{X^*}$, etc., and in particular, h_k is the slope of the isoquant Q_0 , or

$$h_k = - \frac{Q_k}{Q_h} \cdot \frac{24}{\lambda} \quad (22)$$

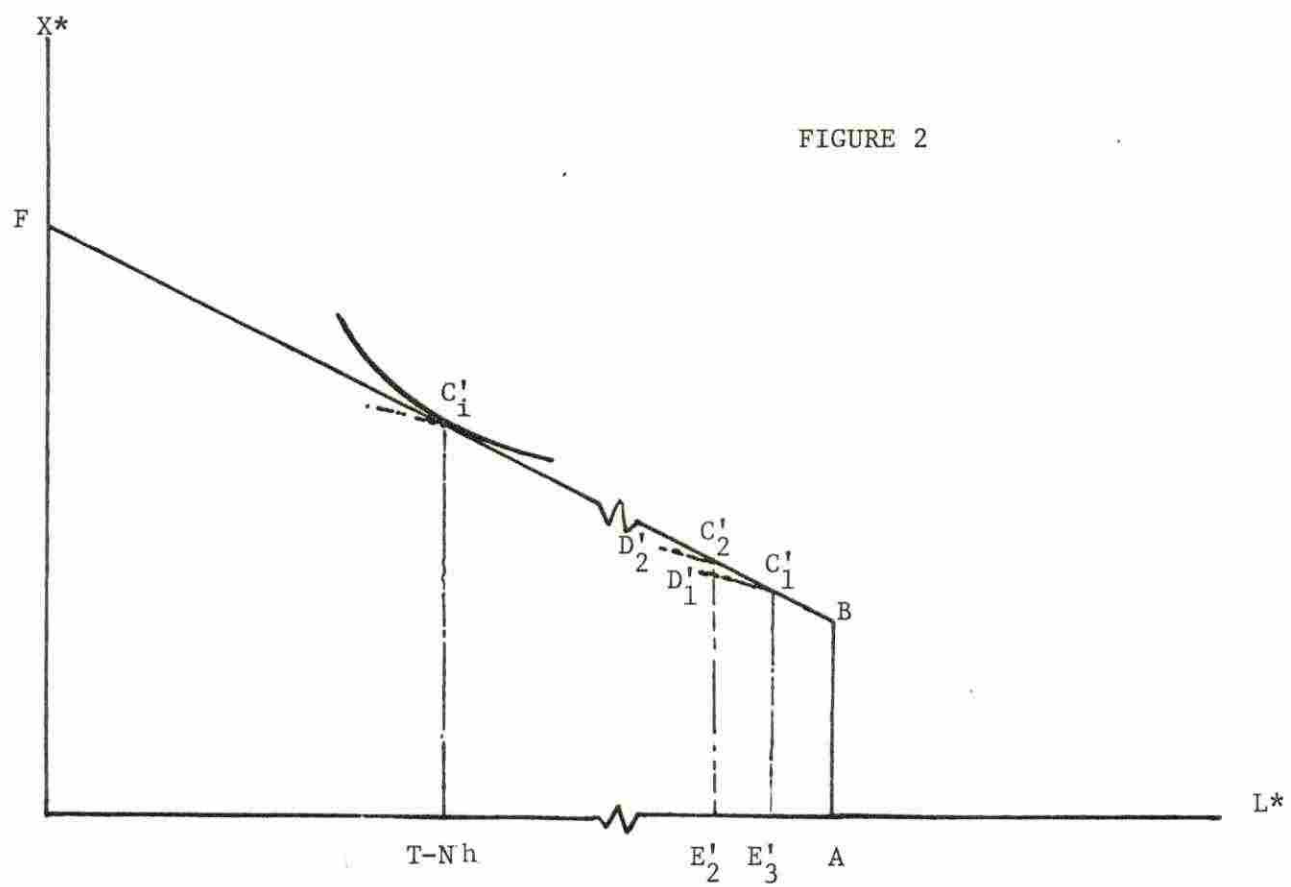
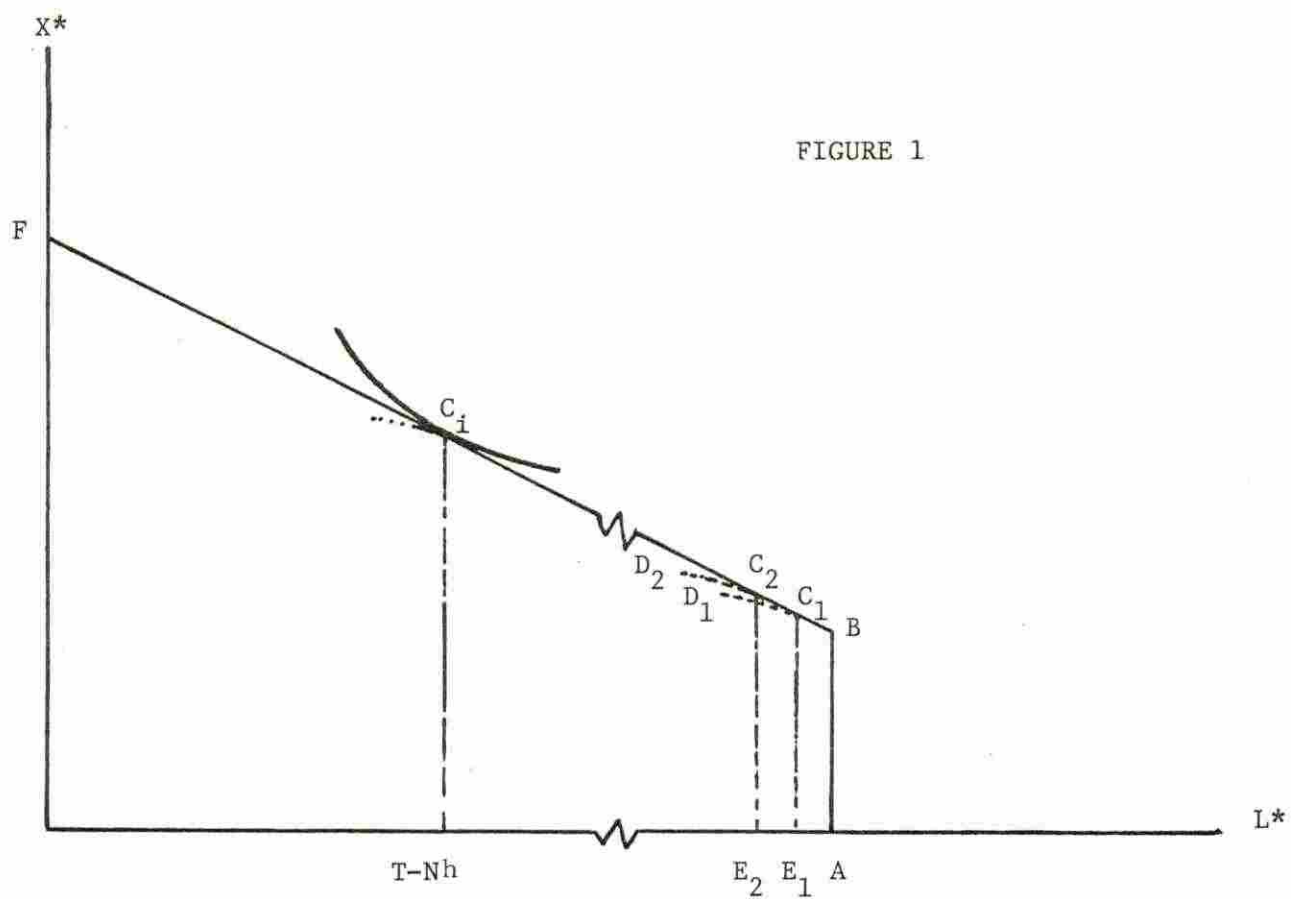
Our discussion of equations (18) through (21) is limited to the unfamiliar conditions, (19) and (20). Equation (19) states that the monetary equivalent of the loss of leisure due to treatment of an additional patient ($U^*_{L^*} h / \lambda$) is equated to the gain in income, or net income per patient ($RQ - S^*k$). Equation (20) states the equality between marginal rates of substitution in consumption and production; put differently, the ratio of the marginal products of h and k equals the ratio of the implicit price of time ($U^*_{L^*} / \lambda^*$) to the market price of other inputs S^* .

A geometric interpretation is given in Figure 1. The physician's budget line is ABF, but the linear earnings segment is based on the assumption that medical care is produced according to constant returns to scale. To see this, note that AE_1 is the physician's time per patient 1, E_1E_2 the physician's time per patient 2, and so on, where all patients receive the same time and care in this illustration. Figure 1 assumes that, as hours per patient 1 increase from A to E_1 and other inputs k increase in proportion, the implicit wage is fixed, which implies a constant returns to scale production function; because, the implicit wage is the value of marginal product RQ_h . The price of care is fixed, implying Q_h fixed as h and k change in equal proportion. Moreover, BF is itself a kind of envelope curve, since patients can demand an amount of care in excess of the actual amount, though at a price less than the market equilibrium. In Figure 1, patient 1 demands an amount of care which given an optimal production decision by the physician implies a derived demand for the physician's time of AE_1 ; beyond AE_1 , the patient's demand price for medical care falls continuously below the market

price, and the value of marginal product also falls continuously, reflecting the decline; this is shown in the figure by segments like C_1D_1 . The physician's hours per patient are flexible above AE_1 , E_1E_2 , etc., in the sense that they could be supplied in excess of those amounts, though the decision would not place the physician on the boundary of his opportunities, and would therefore be inefficient. This discussion also shows that the envelope is really a series of points B, C_1, C_2, \dots, C_N , and is therefore discontinuous, though we assume the hours intervals E_iE_{i+1} are sufficiently small that the discontinuities can be ignored and the physician locates exactly at C_i . The equilibrium indicated at C_i is the graphical depiction of equation (19).

The physician's optimal choice of leisure and market goods under the assumption of constant returns is invariant with respect to equal percentage increases in h and k , accompanied by an equal percentage decrease in N . In other words, the solution is homogeneous of degree zero in h , k , and $\frac{1}{N}$. The proof proceeds in the usual manner: optimality conditions are unchanged if h , k , and N shift as indicated. In particular, the budget constraint is the same, and marginal utilities are the same relative to marginal benefits or marginal costs.^{25/} The economic meaning of this result is that the hours of work decision is separate from the allocation of labor supply decision. In our model, the patient determines the amount of care which he receives, while the physician determines the hours spent per patient through optimal production decisions, constrained by the level of per capital medical care (see the discussion surrounding equation (17) above). Indirectly, therefore, the patient determines physician hours per patient, while the physician entirely determines total work hours, and the size of practice is jointly determined.

The invariance property which we have discussed is shown in Figure 2. In comparison with Figure 1, total work hours remain the same (ignoring



discontinuities), more hours are spent per patient, assuming an increase in individual demands, and fewer patients are treated. The market price of medical care is unchanged, reflecting a hidden assumption that the number of physicians has risen to meet any net increase in the total demand for care.

Comparative statics of the model are appealingly simple. An increase in the market price of medical care R has the usual income and substitution effects on total working time.^{26/} Total working time decreases if leisure is a normal good and the income effect dominates: the geometric interpretation is shown in Figure 4. We assume in that diagram a net increase in the slope of the budget line, though we should make it clear that the slope is endogenous to the model.^{27/} It is clear that the slope of the indifference curve U_1 through the point K must be steeper than the slope of the new budget line and the slope of the indifference curve through the point J . The converse holds in Figure 3.

The effect of a rise in R on hours per patient depends wholly on the impact of the shift on the price of time ($U_{L^*}^* / \lambda^*$), as equation (20) shows clearly, since

$$h_k = - \frac{Q_k}{Q_h} = - \frac{S^*}{U_{L^*}^* / \lambda^*} \quad (23)$$

But the price of time must increase, since hours per patient must decrease, due to an implicit rise in the comparative resource cost of h .^{28/} Moreover, the slope of the physician's indifference curve must be higher in the new equilibrium position, since the slope of the indifference curve is higher when the price of time is higher.^{29/}

Therefore, even if income effects dominate, implying that total hours of work decrease, size of practice may increase if there is a sufficient decline

in hours per patient, the quantity of medical care per patient held constant.^{30/}

If the price of other medical care inputs rises, these inputs decrease, hours per patient increase, and size of practice may decrease. Whether the size of practice decreases depends on the response to the downward rotation of the budget line which follows because the decline in the marginal product of labor implies the income and substitution effects of a falling wage (RQ_h declines, R constant). If total work hours increase, size of practice may also increase, even though more time is spent with the individual patient.

Of course, it is crucial to consider in each case the reasons why a change occurred. Thus if market price R increases, Q may also increase, because market demand rises along an imperfectly elastic supply. Therefore, to analyze this case more fully, the loosening of the Q constraint must be incorporated into our reasoning. In the case at hand, it would simply mean that a sufficient rise in Q could eliminate the decline in hours per patient, leading to a clear reduction in the size of practice.

Some implications for public policies with respect to medical care follow from this analysis. Let medical care to the patient be subsidized, raising the quantity of care per patient; then, for the moment holding the price of care constant, physician hours per patient increase and practice decreases, as we proved earlier. However, a sufficient rise in the price of medical care brought about by the subsidy through an increase in patient demand could decrease physician hours per patient and even increase the size of practice, if hours per patient fell by more than total physician hours, assuming a dominance of income effects as the physician's implicit wage rises. A subsidy specifically aimed at other inputs into medical care than the physician's time decreases hours per patient and total physician work hours if the income effect of a rising implicit wage again dominates. Such subsidies may increase the size of practice.

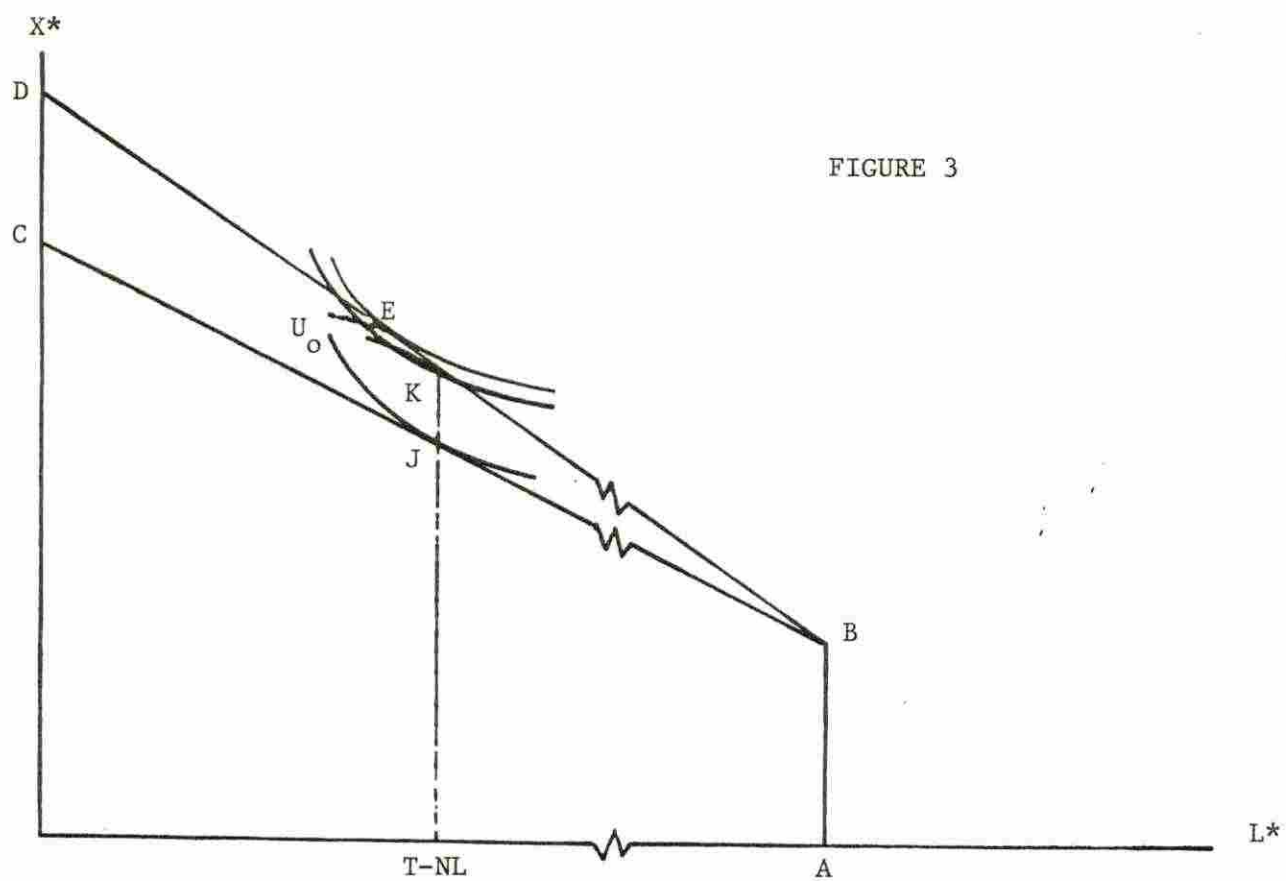


FIGURE 3

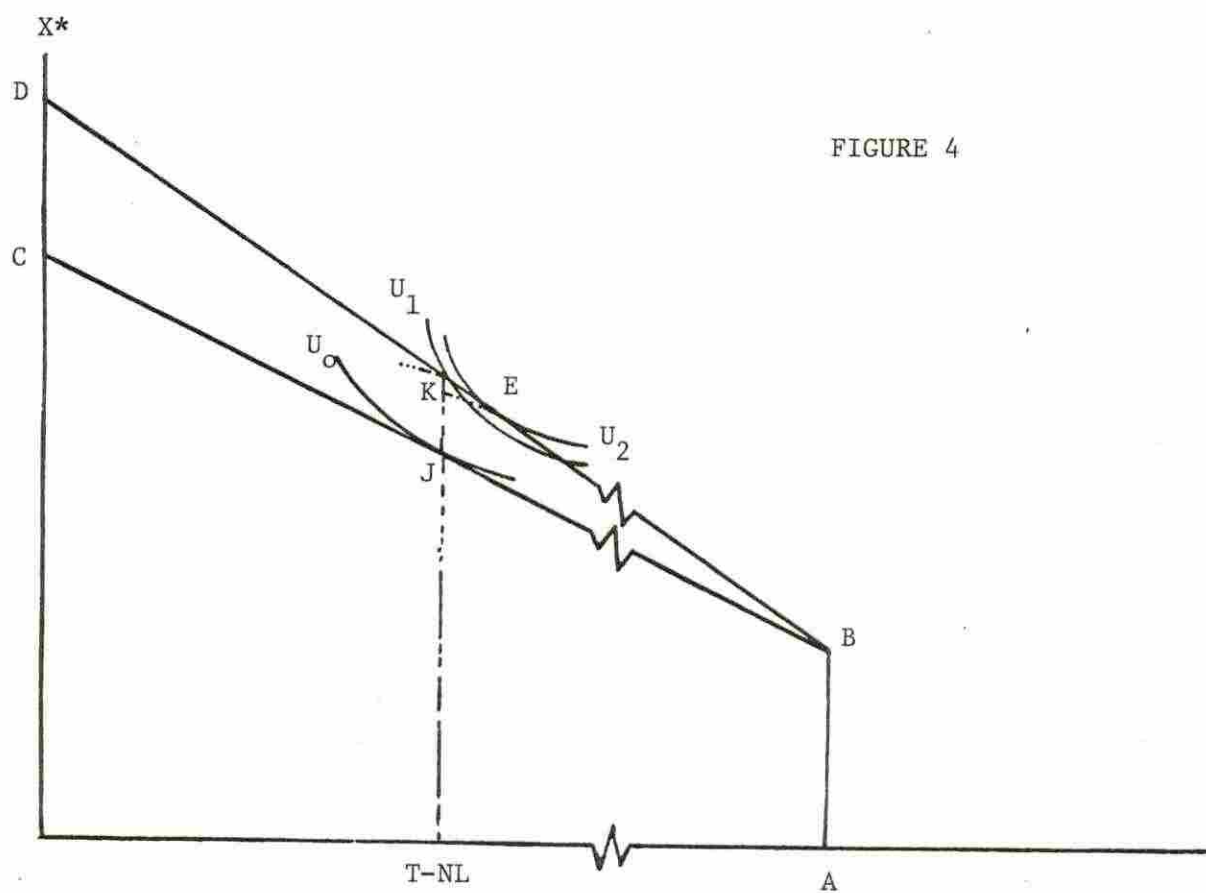


FIGURE 4

Moreover, the model implies equilibrium geographic differentials in the method of providing medical care and also the size of practices. If the price of other inputs k differs systematically across areas, it is nevertheless true that the implicit wage of physicians ($RQ/h - S*k/h$) must be the same as long as the areas are part of a single market for physicians. Therefore, the price of care should be higher where the price of other inputs is higher, less care is provided to each patient because of the greater expense, and practice size tends to be larger in those areas, since total labor supply is the same under the assumption of a single wage.

This concludes the theoretical analysis.

APPENDIX

Part A

The Patient's Model

First order conditions of the patient's utility maximizing problem are

$$\begin{aligned}
 U_L - \lambda W &= 0 \\
 U_X - \lambda P &= 0 \\
 R - (W'H + WF') I_Q &= 0 \\
 W - (W'H + WF') I_M &= 0 \\
 WH + V - PX - \sum_j R_j Q_j &= 0
 \end{aligned} \tag{A.1}$$

for the simple case where healthy time does not enter the patient's utility ($U_F = 0$) and there is a single quality of care. Differentiating (A.1) totally we obtain the displacement system

$$\begin{bmatrix}
 U_{LL} & U_{LX} & 0 & 0 & -W \\
 U_{LX} & U_{XX} & 0 & 0 & -P \\
 0 & 0 & \frac{\partial \Pi_I I_Q}{\partial Q} & \frac{\partial \Pi_I I_Q}{\partial M} & 0 \\
 0 & 0 & \frac{\partial \Pi_I I_M}{\partial Q} & \frac{\partial \Pi_I I_M}{\partial M} & 0 \\
 -W & -P & 0 & 0 & 0
 \end{bmatrix} \cdot \begin{bmatrix} dL \\ dX \\ dQ \\ dM \\ d\lambda \end{bmatrix} = 0$$

$$\begin{bmatrix}
 dw \\
 dp \\
 dR - HI_Q dw' - F' I_Q dw \\
 dW - HI_M dw' - F' I_M dw \\
 -dV - HdW + WdR
 \end{bmatrix}
 \quad (A.2)$$

Using Cramer's Rule to solve for the appropriate derivatives, we obtain

$$\begin{aligned}
 \frac{\partial Q}{\partial W} = & - \frac{\partial Q^S}{\partial \Pi_I I_Q} \left(HI_Q \frac{dW'}{dW} + F' I_Q \right) \\
 & + \frac{\partial Q^S}{\partial \Pi_I I_M} \left(1 - HI_M \frac{dW'}{dW} - F' I_M \right),
 \end{aligned}
 \quad (A.3)$$

$$\text{Where} \quad HI_Q \frac{dW'}{dW} + F' I_Q \geq 0 \quad (A.4)$$

$$1 - HI_M \frac{dW'}{dW} - F' I_M \geq 0 \quad (A.5)$$

Now $\frac{\partial Q^S}{\partial \Pi_I I_Q} < 0$, while $\frac{\partial Q^S}{\partial \Pi_I I_M} > 0$, if Q and M are substitutes in produc-

tion. Thus $\frac{\partial Q}{\partial W} > 0$.

Part B

The Physician's Model

First order conditions in the no-fatigue case are

$$\begin{aligned}
 U_{X^*}^* - P^* &= 0 \\
 - U_{X^*}^* h + (RW - S^*k) &= 0 \\
 - NU_{L^*k}^* h - NS^* &= 0 \\
 V^* + N(RQ - S^*k) - P^*X^* &= 0.
 \end{aligned}
 \tag{B.1}$$

Manipulation of the second and third conditions of (B.1) reveals that

$$\frac{h}{k} = \frac{Qk}{Qh} \left(\frac{R}{S^*} \frac{Q}{k} - 1 \right),
 \tag{B.2}$$

so that the ratio of hours per patient to other inputs is independent not only of marginal utilities, but also of the size of practice N . In fact it depends solely on technology, as revealed by the average and marginal products Q/k , Qk/Qh ; and on the price ratio R/S^* .

Under the assumption of constant returns to scale

$$Q = Q(h,k) = k Q(h/k, 1) = kg(h/k),
 \tag{B.3}$$

$$\text{and } Qh = g'(h/k), \quad Qk = g - h/kg'(h/k).
 \tag{B.4}$$

Using the symbols $\Phi = h/k$, and $\rho = R/S^*$, the direction of shift in Φ is found through implicit differentiation of (B.2):

$$d\Phi = \left[-\frac{\Phi g g''}{(g')^2} (\rho g - 1) + \frac{g - \Phi g'}{g'} \rho g' \right] \cdot d\Phi \\ + \frac{g - \Phi g'}{g'} g d\rho . \quad (B.5)$$

Substituting

$$\rho g - 1 = \frac{\Phi g'}{g - \Phi g'} , \quad \rho = \frac{1}{g - \Phi g'}$$

into (B.5) and solving for the derivative,

$$\frac{d\Phi}{d\rho} = \frac{(g - \Phi g')^2}{\Phi g''} \quad (B.6)$$

which is negative if the marginal product of hours per patient is diminishing, implying $g'' < 0$. Thus, as $\rho = R/S^*$ increases, $\Phi = h/k$ decreases, and vice versa.

Since we have proved that h and k depend only on R , S^* , Q , and technology, we write

$$h = m(R, S^*, Q, \beta) \quad (B.7)$$

$$k = n(R, S^*, Q, \beta), \quad (B.8)$$

where β is the vector of technological shift parameters introduced in the text, and $m_R < 0$, $m_{S^*} > 0$, $n_R > 0$, $n_{S^*} < 0$ as we have shown, while $m_Q, n_Q > 0$, if h and k are normal factors.

To derive comparative statics results, we prefer to maximize utility through optimal choice of X^* and L^* on the assumption that (B.2) is satisfied

and differentiate these first order conditions. In other words, we assume optimal production decisions on the use of h and k have already been made, so that net income has been maximized at constant leisure and constant total working time, which can be shown to imply (B.2). We prefer this procedure over the computationally more difficult alternative of differentiating (B.1) directly.

The utility maximizing problem is simply

$$L = U^*(X^*, L^*) + \lambda^* [V^* + (T-L^*) (RQ/h - S^* k/h) - P^* X^*], \quad (B.9)$$

where we have used the fact that $N = (T-L^*)/h$. First order conditions are

$$\begin{aligned} U_{X^*}^* - \lambda^* P^* &= 0 \\ U_{L^*}^* - \lambda^* (RQ/h - S^* k/h) &= 0 \\ V^* + (T-L^*) (RQ/h - S^* k/h) - P^* X^* &= 0. \end{aligned} \quad (B.10)$$

Differentiating (B.10) totally with respect to R and S^* we obtain the displacement system

$$\begin{bmatrix} U_{X^* X^*}^* & U_{X^* L^*}^* & -P^* \\ U_{X^* L^*}^* & U_{L^* L^*}^* & -(RQ/h - S^* k/h) \\ -P^* & -(RQ/h - S^* k/h) & 0 \end{bmatrix} \begin{bmatrix} dX^* \\ dL^* \\ d\lambda^* \end{bmatrix} = \quad (B.11)$$

$$\begin{bmatrix} 0 \\ \lambda^* [Q/h \, dR + R \frac{\partial(Q/h)}{\partial R} \, dR + R \frac{\partial(Q/h)}{\partial S^*} \, dS^* - k/h \, dS^* \\ - S^* \frac{\partial(k/h)}{\partial R} \, dR - S^* \frac{\partial(k/h)}{\partial S^*} \, dS^*] \\ - (T - L^*) [Q/h \, dh + R \frac{\partial(Q/h)}{\partial R} \, dR + R \frac{\partial(Q/h)}{\partial S^*} \, dS^*] \\ + (T - L^*) [k/h \, dS^* + S^* \frac{\partial(k/h)}{\partial R} \, dR + S^* \frac{\partial(k/h)}{\partial S^*} \, dS^*] \end{bmatrix}$$

We have shown that $d(h/k) / d(R/S^*) < 0$; hence,

$$\frac{\partial(Q/h)}{\partial R} = \frac{d(Q/h)}{d(k/h)} \frac{d(h/k)}{d(R/S^*)} \frac{1}{S^*} > 0 \quad (B.12)$$

$$\frac{\partial(Q/h)}{\partial S^*} = - \frac{d(Q/h)}{d(h/k)} \frac{d(h/k)}{d(R/S^*)} \frac{R}{S^{*2}} < 0 \quad (B.13)$$

since $\frac{d(Q/h)}{d(h/k)} < 0$. Also we have that

$$\frac{\partial(k/h)}{\partial R} < 0, \quad -\frac{\partial(k/h)}{\partial S^*} > 0.$$

Hence, for the second and third lines of the vector of exogenous changes for (B.11) we have proved that

$$\frac{\partial(RQ/h - S^*k/h)}{\partial R} > 0, \quad \frac{\partial(RQ/h - S^*k/h)}{\partial S^*} < 0.$$

Using Cramer's Rule to solve for changes in L^* , and writing $\Pi_{L^*} = RQ/h - S^*k/h$ for the price of leisure,

$$\frac{\partial L^*}{\partial R} = \left(\frac{\partial L^{*S}}{\partial \Pi_{L^*}} + (T - L^*) \frac{\partial L^*}{\partial I} \right) \frac{\partial \Pi_{L^*}}{\partial R} \quad (B.14)$$

$$\frac{\partial L^*}{\partial S^*} = \left[\frac{\partial L^{*S}}{\partial \Pi_{L^*}} + (T - L^*) \frac{\partial L^*}{\partial I} \right] \frac{\partial \Pi_{L^*}}{\partial S^*}, \quad (B.15)$$

where $\frac{\partial L^{*S}}{\partial \Pi_{L^*}} < 0$, $\frac{\partial L^*}{\partial I} > 0$, and $\frac{\partial \Pi_{L^*}}{\partial R} > 0$, $\frac{\partial \Pi_{L^*}}{\partial S^*} < 0$

Hence if income effects dominate, L^* increases with R because we have shown that Π_{L^*} rises with R ; on the same premise L^* falls as S^* increases,

since Π_{L^*} falls as S^* increases. Thus we have shown that the usual income and substitution effects pertain for leisure.

Notice that since $\partial h / \partial R < 0$, $\partial h / \partial S^* > 0$,

$$\frac{\partial N}{\partial R} = - \left(\frac{(\pm)}{\partial R} \frac{\partial L^*}{\partial R} + \frac{(-)}{\partial R} \frac{\partial h}{\partial R} N \right) \frac{1}{h} \quad (B.16)$$

$$\frac{N}{S^*} = - \left(\frac{(\pm)}{S^*} \frac{\partial L^*}{\partial S^*} + \frac{(+)}{S^*} \frac{\partial h}{\partial S^*} N \right) \frac{1}{h} \quad (B.17)$$

can be determined residually.

FOOTNOTES

- 1 This analysis is clearly applicable to the supply of legal services, and many other kinds as well. Note that the difficulty of resale introduces the possible complication of price discrimination.
- 2 Each of these models of multiple job holding may be the more reasonable in its own context. In an industrial setting, the model of Shisko and Rostker may be more reasonable, since it treats hours of work as variable up to a maximum, which accords with the (legislated?) scarcity of over-time hours in normal periods, and the flexibility of industrial working hours provided by the option of switching employers and job titles. The wage in each job is treated as fixed up to a maximum, and thereafter zero, implying a demand curve for hours of work in each job which is downward sloping in extreme, step-function form. Huffman's model was developed to analyze the off-farm labor supply of farm people, and treats wages in either farm or off-farm work as perfectly flexible. Due to the presence of fixed factors on the farm, the marginal wage falls continuously in farm work; the wage is constant in off-farm work. The perfectly flexible hours assumed in Huffman are more reasonable for self-employed workers.
- 3 Feldman (1975) uses the Hedonic Hypothesis to analyze these quality variations.
- 4 Moreover, quality variation raises to at least three the number of competing explanations for price variation in medicine: price discrimination, information, and quality variation.
- 5 Fuchs (197) finds significant effects of health on wage rates.
- 6 Our model is cast in a static framework. With the exception of patient's age, life cycle variables are not included in our study. Later age can be treated as shifting the marginal cost of any level of health upwards so levels of health diminish from one period to the next due to diminishing net investments in health. Of course, if the demand for health is sufficiently inelastic, gross investments can rise, since the demand for health falls less than the supply, leading to a rise in the demand for medical care.
- 7 If investments in health are possible even if no medical care is purchased $I = I(S, 0, 0, \dots, 0) > 0$; but if no patient time is devoted to health care, including visits to physicians, no investments are possible, then $I = I(0, Q_1, Q_2, \dots, Q_s) = 0$, $Q_i \neq 0$ for some i . A CRS production function which incorporates these properties is

$$I = S^{1-\alpha} [S^\alpha + (\sum_{j=1}^s V_j Q_j)^\alpha],$$

which exhibits diminishing marginal productivity if positive amounts of S and at least one of the Q_j are purchased.

- 8 Part A of the Appendix derives the comparative statics of the demand for medical care.
- 9 Jobs which require unusual effort may offer wages which are more responsive to health, thereby providing incentives to purchase medical care, even if average wages are the same as those paid in less strenuous work. For an interesting analysis of the allocation of effort, see Becker (1977). Since there is also some evidence that jobs which require more effort also pay higher wages [see for example Edward Lazear (197), and Robert E.B. Lucas (1977)], we are assuming an increase in other amenities supplied by the more effort-intensive job.
- 10 A positive correlation between wage rates and earnings is implied by the normality of market goods, which restricts the extent to which the individual's labor supply curve can bend backwards.
- 11 Grossman (1972, pp. 55-63) uses family income as an explanatory variable in a regression which estimates the demand for medical care. Since the wage rate is held constant, he interprets the positive sign of the coefficient on family income as a nonwage income effect. (197) fail to find any effect of nonwage income on the demand for medical care.
- 12 In Section III we explicitly show how the per capita level of medical care determines physician hours per patient.
- 13 The population aggregate is still assumed to be small relative to the market for medical care, as in the case of a Census Tract.
- 14 This "Austrian" dimension of medical care presumably can be explained by the importance of time in adding to health.
- 15 The education differential would be entered in a regression stratified by type of medical care, which would include patient's education, income, age, and sex as additional explanatory variables.
Use of the differential is defended by the standard argument that one component of economic value of education is its usefulness in assimilating new information. Therefore, the more educated patients are relative to physicians, the less are the number of repeat visits, severity of illness held constant, assuming the hypothesis of supply-induced demand is valid.
- 16 Demand for medical care must cut supply from below to exhibit Walrasian stability.
- 17 To test for the importance of search, price variability can be regressed against a measure of the patient's level of demand, such as the number of visits per year.
- 18 Physician variables are written with an asterick wherever there are counterparts for the patient.

- 19 For the case of m qualities of care supplied by the physician, the budget line is

$$Y = V^* + \sum_{i=1}^m N_i R_i(\alpha_i) Q_i[h_i, k_i, \sum_{j=1}^m N_j(h_j + f_j), \beta_i] - \sum_{i=1}^m N_i S_i^* k_i.$$

- 20 Measures of availability such as hospital or clinic affiliation probably do not reflect physician skills. Instead they seem to be indicators of cost: the greater is the distance from a hospital, the less likely is hospital affiliation. In other words, affiliation is a 0-1 decision based on latent cost components. Since associations do affect the amount of care, however, we prefer to treat them as determinants of form of the the production function rather than disregard them completely.

- 21 In the m -component case, the time budget, including fixed costs f_{i*} is

$$T^* = L^* + \sum_{i=1}^m N_i(h_i + f_i)$$

- 22 Again, in the case where a practice entails m qualities of care, the Lagrangean function is

$$L = U^* [X^*, T^* - \sum_{i=1}^m N_i(h_i + f_i)] + \lambda^* [V^* + \sum_{i=1}^m N_i R_i(\alpha_i) Q_i(h_i, k_i, \sum_{j=1}^m N_j(h_j + f_j), \beta_i) - \sum_{i=1}^m N_i S_i^* k_i - P^* X^*].$$

First order conditions of this problem obviously include equations showing equality of value of marginal product of per patient hours and size of practice for any two qualities of care, abstracting from differential effects upon the physician's utility.

- 23 No explicit cost of time appears to determine the level of h because we are assuming that the price of time, $U_{L^*}^* / \lambda^*$ exceeds the alternative wage. Thus $U_{L^*}^* / \lambda^*$ is the opportunity cost of time. For equal amenities, total earning and the wage in the practice exceed their counter parts in the physician's alternative job. More generally, we assume his utility is highest when a physician.

- 24 In the case where fatigue exists, $Q = Q(h, k, hN, \beta)$, $Q_{H^*} < 0$, and $h = h(k, N, Q_0, \beta)$. Also we have that

$$h_k = \frac{\partial h}{\partial k} = - \frac{Q_k}{Q_h + Q_{H^*} N}.$$

Similary,

$$h_N = - \frac{Q_{H^*} h}{Q_h + Q_{H^*} N},$$

where equations (19) and (20) are appropriately altered to include these derivatives.

25

The conclusion holds where there is fatigue provided the effects of fatigue are proportionate the level of output. Writing our equations (19) and (20) in full using the results of fn. 24 [(18) and (21) remain the same] we have

$$-U_{L^*}^* \left(h - \frac{NLQ_{H^*}}{Q_h + Q_{H^*} N} \right) + \lambda^* (RQ - S^*k) = 0, \quad (19)'$$

and

$$U_{L^*}^* \frac{NQk}{Q_h + Q_{H^*} N} - \lambda^* NS^* = 0 \quad (20)'$$

If the effects of fatigue are constant per unit of output, and h , k , and Q expand in the proportion $\beta > 1$, while N contract in the proportion $1/\beta$ then each of these conditions remains the same. Constant returns to scale pertain, so that Q_h and Q_k are unchanged.

The proportionality assumption implies that $Q_{H^*1} = \beta Q_{H^*0}$ if $Q_1 = \beta Q_0$ and also that $N_1 Q_1 = N_0 Q_0$, thus holding constant total effects of fatigue. But if total work hours remain constant, why should there be a different total output?

26

A sufficient increase in consumer demand is assumed so that care per patient Q is constant.

27

The price of leisure is $\Pi_{L^*} = \frac{1}{h} (RQ - S^*k)$, or net revenue per hour; it is shown in the Appendix, Part B that Π_{L^*} rises as R rises, and decreases as S^* rises. Thus the equilibrium slope of the budget line rises.

The condition for this to hold is that the marginal product of L diminishes.

28

See the Appendix, Part B and the preceding footnote.

29

The proof is simple:

$$\frac{U_{L^*}^*}{U_{X^*}^*} = \frac{U_{L^*}^* / \lambda^*}{U_{X^*}^* / \lambda^*} = \frac{U_{L^*}^* / \lambda^*}{P^*}$$

Thus the slope of the indifference curve is higher, since P^* has

been assumed to be unchanged, when the price of time increases.

30

Clearly k increases as h decreases. In every case, the effects on k are the reverse of the effects on h , since Q is assumed constant.